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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	Saranathan et al.
Serial No.	:	10/605,645
Filed	:	October 15, 2003
For	:	METHOD AND APPARATUS FOR ENHANCED MAGNETIC PREPARATION IN MR IMAGING
Group Art No.	:	3768
Examiner	:	Salieu M. Abraham

CERTIFICATION UNDER 37 CFR 1.8(a) and 1.10

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APPEAL BRIEF PURSUANT TO 37 C.F.R §41.37

Dear Sir:

This Appeal Brief is being filed in furtherance of the Notice of Appeal filed on October 9, 2008.

1. **REAL PARTY IN INTEREST**

The real party in interest is General Electric Company by virtue of the Assignment recorded April 20, 2004, at reel 016212, frame 0534.

2. **RELATED APPEALS AND INTERFERENCES**

Appellant is unaware of any other appeals or interferences related to this Appeal. The undersigned is Appellant's legal representative in this Appeal. General Electric Company, the Assignee of the above-referenced application, as evidenced by the documents mentioned above, will be directly affected by the Board's decision in the pending appeal.

3. **STATUS OF CLAIMS**

Claims 1, 2, 4-14, and 16-25 are pending in the present application. Claims 1, 2, 4-14, and 16-25 are currently under final rejection. Claims 1, 2, 4-14, and 16-25 are the subject of this appeal.

4. **STATUS OF AMENDMENTS**

All previous amendments have been entered. Appellant has submitted no additional amendments subsequent to the Final Office Action of May 16, 2008.

5. **SUMMARY OF CLAIMED SUBJECT MATTER**

Claim 1 calls for a method of MR imaging comprising the steps of partitioning k-space (80) into a number of partitions (82, 84, 86), wherein the partitions (82, 84, 86) incrementally increase in distance from a center of k-space (80). *Specification,* ¶[0031], Fig. 3. The method further comprises applying magnetic preparation pulses (72) and acquiring data in an elliptic centric acquisition order, such that a rate by which the magnetic preparation pulses (72) are applied is a function of the incremental distance a partition of MR data is from the center of k-space (80). *Specification,* ¶¶[0026-0029], Fig. 2. The method of MR imaging also includes playing out a dummy acquisition (74) following each of the magnetic preparation pulses (72). *Specification,* ¶[0030], Fig. 2.

An MRI apparatus, as called for in claim 11, comprises a magnetic resonance imaging (MRI) system (10) having a plurality of gradient coils (50) positioned about a bore of a magnet (54) to impress a polarizing magnetic field and an RF transceiver system (58) and an RF switch (62) controlled by a pulse module (38) to transmit RF signals to an RF coil assembly (56) to acquire MR images. *Specification,* ¶¶[0022-0024], Fig. 1. The MRI apparatus further comprises a computer (20) programmed to partition k-space (80) into a number of partitions (82, 84, 86), each having an increased distance from a center of k-space (80), apply magnetic preparation pulses (72) at a first rate during data acquisition for a first radial partition, and apply magnetic preparation pulses (72) at a second rate, different from the first rate, during data acquisition for a second partition. *Specification*, ¶¶[0026-0029, 0031], Figs. 2-3. The computer (20) is also programmed to play out a dummy acquisition (74) following each of the magnetic preparation pulses (72). *Specification,* ¶[0030], Fig. 2.

Claim 20 calls for a computer readable storage medium having stored thereon a set of instructions that when executed by a computer causes the computer to partition k-space data (80) into a number of partitions (82, 84, 86), each a given distance from a center of k-space (80). *Specification*, ¶[0031], Fig. 3. The computer also plays out a magnetic preparation pulse (72) at a different rate for each partition (82, 84, 86), the rate being dependent on a given distance a partition is from the center of k-space (80), acquires MR data (76) in an elliptic centric order, and plays out a dummy acquisition (74) following each of the magnetic preparation pulses (72). *Specification*, ¶¶[0029-0030], Figs. 2-3.

6. **GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL**

In the Final Office Action mailed May 16, 2008, the Examiner rejected claims 1, 2, 4-6, 9, 10, and 20-25 under 35 U.S.C. §103(a) as being unpatentable over Ookawa (US Pub. 2001/0004211) in view of Laub (USP 6,380,740), and further in view of Jezzard, Peter "Physical Basis of Spatial Distortions in Magnetic Resonance Images." in: Bankman, Isaac N., Handbook of Medical Imaging Processing and Analysis (San Diego, Academic Press, 2000), pp. 425-435 (hereinafter Jezzard). The Examiner next rejected

claims 7 and 8 under 35 U.S.C. §103(a) as being unpatentable over Ookawa in view of Laub, further in view of Jezzard, and further in view of Stephen J. Riederer, "Current Technical Development in Magnetic Resonance Imaging," IEEE Engineering in Medicine and Biology Magazine, September/October 2000 (hereinafter Riederer). Claims 11-14, 16, and 18 were rejected under 35 U.S.C. §103(a) as being unpatentable over Mistretta et al. (USP 5,873,825) in view Ookawa, and further in view of Jezzard. Claim 17 was rejected under 35 U.S.C. §103(a) as being unpatentable over Mistretta et al. in view of Ookawa, further in view of Jezzard, and further in view of Riederer. Claim 19 was rejected under 35 U.S.C. §103(a) as being unpatentable over Mistretta et al. in view Ookawa, further in view of Jezzard, and further in view of Laub.

7. **ARGUMENTS**

Claim Rejections under 35 U.S.C. §103(a)

Claim 1

Considering claims 1, 2, 4-6, 9, 10, and 20-25, the Examiner rejected the claims under 35 U.S.C. §103(a) as being unpatentable over Ookawa in view of Laub, further in view of Jezzard. In rejecting independent claim 1, the Examiner stated that Ookawa in view of Laub teaches every limitation with the exception of "playing out a dummy acquisition following each of the magnetic preparation pulses." *See Final Office Action*, May 16, 2008, p. 6. To teach this limitation, the Examiner relied upon Jezzard and stated that Jezzard "teaches the application of a delay which is determined by applying dummy acquisitions or scans in order to allow spins to have reached a steady state when the image signal is detected and to curtail non-frequency-encoded (e.g. phase –and/or slice encode) derived artifact or noise." *Id.* Appellant respectfully disagrees with the Examiner's characterization of the teachings of the Jezzard reference.

First, while the Examiner contended that Jezzard is in the same field of endeavor as both Ookawa and Laub, Jezzard simply addresses spatial distortions in conventional magnetic resonance imaging. *See Jezzard*, Sections 6.1 - 6.2, pp. 433-434. However, Jezzard does not disclose the use of magnetic preparation pulses prior to data acquisition, and Jezzard also fails to teach the elliptical centric phase ordered acquisition of

Appellant's invention. That is, the MR data acquisition method disclosed by Jezzard is simply a conventional method for collecting MR data, wherein all phase-encode lines in k-space are collected sequentially. *See Jezzard*, p. 427, Fig. 1. However, in Appellant's elliptical centric phase ordered acquisition, k-space is reordered such that data is acquired in an order of increasing k-space radial distance, meaning that data in the central region of k-space is acquired before the periphery of k-space is acquired. *See Specification*, Para. [0004]. As such, it would not have been obvious to one of ordinary skill in the art to have incorporated the conventional MR data acquisition and generalized dummy scan acquisitions of Jezzard with the alleged elliptical centric phase ordered acquisition of Ookawa in view of Laub, as Jezzard is drawn to a completely different method of MR data acquisition than that which is claimed.

Further, even if the teachings of Jezzard were analogous to the teachings of Ookawa in view of Laub, Jezzard does not disclose "playing out a dummy acquisition following <u>each</u> of the magnetic preparation pulses", as is called for in claim 1. Jezzard merely states that "[a] well-designed pulse sequence will incorporate enough 'dummy scan' acquisitions that when the image signal is detected, the spins have reached a steady state." *Jezzard*, Section 6.2, p. 434. Simply because Jezzard may suggest some of the benefits of playing out enough dummy scans," does not equate to a teaching of when, where, or how many such dummy scans should be played out, and thus does not signify that the teachings of Jezzard are sufficient to teach one skilled in the art how to practice the invention as claimed. For example, nowhere does Jezzard suggest that these "dummy scan" acquisitions are to be played out prior to data acquisition, let alone following <u>each</u> magnetic preparation pulse, as is called for in claim 1. In fact, Jezzard does not even disclose the use of magnetic preparation pulses in conjunction with dummy acquisitions, and specifically the playing out of dummy acquisitions following <u>each</u> magnetic preparation pulse. Appellant discloses that magnetic preparation pulses are applied at a variable rate to suppress magnetization in a tissue prior to MR data acquisition, while the dummy acquisitions are played out following each magnetic preparation pulse so as to reduce ghosting artifacts associated with steady state effects. *See Specification*, Para. [0026, 0030]. Jezzard merely teaches incorporating "enough" dummy scan acquisitions

into a pulse sequence, without ever defining the frequency or pattern of the dummy scan acquisitions so as to provide a benchmark for what is considered "enough". *See Jezzard*, Section 6.2, p. 434. As Appellant's Specification discloses, playing out dummy acquisitions following each magnetic preparation pulse "may greatly improve image quality with the reduction of ghosting artifacts typically associated with steady state effects." *See Specification*, Para. [0030]. As Jezzard fails to even teach or suggest the playing out of magnetic preparation pulses and acquiring data in elliptic centric order, the Jezzard reference, in combination with Ookawa in view of Laub, cannot reasonably teach or suggest "playing out a dummy acquisition following each of the magnetic preparation pulses."

Accordingly, in view of the above, Appellant believes that the Examiner has failed to show that the combination of Ookawa in view of Laub further in view of Jezzard teaches or suggests each and every limitation of claim 1. As such, Appellant respectfully requests that the Board render a favorable decision and order the withdrawal of the rejection of claim 1, along with the withdrawal of the rejections to all claims dependent therefrom.

Claim 11

Claims 11-14, 16, and 18 were rejected under 35 U.S.C. §103(a) as being unpatentable over Mistretta et al. in view Ookawa, and further in view of Jezzard. In regard to claim 11, the Examiner alleged that Mistretta et al. in view of Ookawa teaches every limitation of the claim except for the step that the computer is programmed to "play out a dummy acquisition following each of the magnetic preparation pulses." *See Final Office Action, supra at 19*. Once again, however, the Examiner stated that the Jezzard reference "has been shown to teach playing out a dummy acquisition following each of the magnetization pulses." *Id*. However, as was set forth above with respect to claim 1, the Jezzard reference does not sufficiently teach or suggest the missing limitations of claim 11. Specifically, the Jezzard reference merely discloses that "[a] well-designed pulse sequence will incorporate enough 'dummy scan' acquisitions that when the image signal is detected, the spins have reached a steady state." *Jezzard*, Section 6.2, p. 434.

Nowhere does Jezzard suggest that these "dummy scan" acquisitions be played out following each magnetic preparation pulse, as is specifically called for in claim 11. In fact, Jezzard does not even disclose the use of magnetic preparation pulses in conjunction with dummy acquisitions, let alone the use of dummy acquisitions following each magnetic preparation pulse. As discussed above with respect to claim 1, the magnetic preparation pulses are applied at a variable rate to suppress magnetization in a tissue prior to MR data acquisition, while the dummy acquisitions are played out following each magnetic preparation pulse so as to reduce ghosting artifacts associated with steady state effects. *See Specification*, Para. [0026, 0030]. Jezzard merely teaches incorporating "enough" dummy scan acquisitions into the pulse sequence, without ever defining the frequency or pattern of the dummy scan acquisitions. *Id*. Clearly, the Jezzard reference cannot be shown to teach or reasonably suggest those elements lacking in the Mistretta et al. reference and the Ookawa reference. At best, Jezzard discloses the general concept of "dummy" acquisitions, but nowhere does Jezzard teach or suggest how to implement the dummy acquisitions, nor that they are played out following each magnetic preparation pulse.

Accordingly, in view of the above and further in view of the arguments set forth with respect to claim 1, Appellant believes that the Examiner has failed to show that the combination of Mistretta et al. in view Ookawa, and further in view of Jezzard teaches or suggests each and every limitation of claim 11. As such, Appellant respectfully requests that the Board render a favorable decision and order the withdrawal of the rejection of claim 11, along with the withdrawal of the rejections to all claims dependent therefrom.

Claim 20

Considering independent claim 20, the Examiner stated that "Ookawa in view of Laub does disclose: A computer readable storage medium having stored thereon a set of instructions that when executed by a computer causes the computer to: - play out at least one dummy acquisition during MR data acquisition following each of the magnetic preparation pulses." *Final Office Action*, supra at 12, (emphasis added). Appellant notes that the rejection should have read "Ookawa in view of Laub does not disclose..," -- a

mistake to which the Examiner admitted in the Advisory Action of September 9, 2008. *See Advisory Action*, September 9, 2008, section 5. Regardless of the correction of this error, Appellant still believes that the Examiner's rejection of claim 20 is incorrect, particularly in view of the Examiner's characterization of the Jezzard reference.

As was similarly set forth above with respect to claims 1 and 11, the Jezzard reference merely discloses that "[a] well-designed pulse sequence will incorporate enough 'dummy scan' acquisitions that when the image signal is detected, the spins have reached a steady state." *Jezzard*, Section 6.2, p. 434. Again, nowhere does Jezzard state that these "dummy scan" acquisitions are played out following <u>each</u> magnetic preparation pulse, as is specifically called for in claim 20. In fact, Jezzard does not even disclose the use of magnetic preparation pulses in conjunction with dummy acquisitions. Jezzard only teaches incorporating "enough" dummy scan acquisitions into the pulse sequence such that the spins have reached a steady state with the image signal is detected, without ever defining the frequency or pattern of the dummy scan acquisitions. As discussed above with respect to claims 1 and 11, simply disclosing some benefit of playing out a "dummy scan" is not tantamount to a teaching sufficient to teach one skilled in the art how to practice the invention as claimed. As Jezzard clearly fails to teach or suggest the limitations missing from the combination of Ookawa and Laub, Appellant believes that the rejection to claim 20, like the rejections to claims 1 and 11, is not proper under 35 U.S.C. §103(a).

Accordingly, Appellant believes that the Examiner has failed to show that the combination of Ookawa in view of Laub further in view of Jezzard teaches or suggests each and every limitation of claim 20. As such, Appellant respectfully requests that the Board render a favorable decision and order the withdrawal of the rejection of claim 20, along with the withdrawal of the rejections to all claims dependent therefrom.

8. <u>**CONCLUSION**</u>

For at least the reasons set forth above, Appellant requests withdrawal of the rejections of claims 1, 2, 4-14, and 16-25. Appellant believes that the Examiner has not shown that the art of record teaches each and every limitation of the claims so as to make

the claims obvious. As such, Appellant believes that claim 1, 11, and 20, and claims which depend therefrom, are patentably distinct over the art of record.

Appellant appreciates the Board's consideration of these Remarks and respectfully requests timely issuance of a Notice of Allowance.

Respectfully submitted,

/Timothy J. Ziolkowski/

Timothy J. Ziolkowski
Registration No. 38,368
Phone 262-268-8181
tjz@zpspatents.com

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Attorney Docket No.: GEMS8081.176

P.O. ADDRESS:
Ziolkowski Patent Solutions Group, SC
136 South Wisconsin Street
Port Washington, WI 53074
262-268-8100

CLAIMS APPENDIX

In the claims

1. (Previously Presented) A method of MR imaging comprising the steps of:

partitioning k-space into a number of partitions, wherein the partitions incrementally increase in distance from a center of k-space;

applying magnetic preparation pulses and acquiring data in an elliptic centric acquisition order, such that a rate by which the magnetic preparation pulses are applied is a function of the incremental distance a partition of MR data is from the center of k-space; and

playing out a dummy acquisition following each of the magnetic preparation pulses.

2. (Original) The method of claim 1 wherein the magnetic preparation pulses are saturation pulses, and further comprising the step of decreasing the rate by which the saturation pulses are applied as the distance a partition of MR data is from the center of k-space increases.

3. (Cancelled)

4. (Previously Presented) The method of claim 1 further comprising the step of playing out the magnetic preparation pulses every N_i TR for an ith partition, wherein $N_1 < N_2 \ldots < N_{M-1} < N_M$, and M corresponds to the number of partitions, and wherein every N_i is a non-zero integer.

5. (Original) The method of claim 4 wherein the number of partitions includes three partitions for a given image acquisition, wherein N_i includes $N_1 < N_2$ and $N_2 < N_3$.

6. (Original) The method of claim 5 wherein the step of applying magnetic preparation pulses includes the step of playing out fat saturation pulses every five TRs for the first partition, every 15 TRs for the second partition, and every 40 TRs for the third partition.

7. (Original) The method of claim 1 further comprising the step of determining the number of partitions based on an FOV from which MR data is to be acquired.

8. (Original) The method of claim 7 further comprising the step of determining the number of partitions to minimize k-space discontinuity between adjacent k-space views.

9. (Original) The method of claim 1 wherein the magnetic preparation pulses are fat saturation pulses, and further comprising the step of maximizing fat saturation while minimizing differential weighting of k-space while acquiring central region k-space.

10. (Original) The method of claim 1 wherein the data acquisition in k-space includes a radial acquisition in k-space.

11. (Previously Presented) An MRI apparatus comprising:

a magnetic resonance imaging (MRI) system having a plurality of gradient coils positioned about a bore of a magnet to impress a polarizing magnetic field and an RF transceiver system and an RF switch controlled by a pulse module to transmit RF signals to an RF coil assembly to acquire MR images; and

a computer programmed to:

partition k-space into a number of partitions, each having an increased distance from a center of k-space;

apply magnetic preparation pulses at a first rate during data acquisition for a first radial partition; and

apply magnetic preparation pulses at a second rate, different from the first rate, during data acquisition for a second partition; and

play out a dummy acquisition following each of the magnetic preparation pulses.

12. (Previously Presented) The MRI apparatus of claim 11 wherein the first rate and second rate are a function of partition distance from the center of k-space.

13. (Previously Presented) The MRI apparatus of claim 11 wherein the first rate is greater than the second rate if the first radial partition is closer to the center of k-space than the second radial partition.

14. (Previously Presented) The MRI apparatus of claim 13 wherein the magnetic preparation pulse is a saturation pulse.

15. (Cancelled)

16. (Previously Presented) The MRI apparatus of claim 11 wherein the magnetic preparation pulses include at least one of a fat saturation pulse, an IR pulse, and a spatial saturation RF pulse.

17. (Previously Presented) The MRI apparatus of claim 11 wherein the computer is further programmed to determine dimensions of an FOV and, from the dimensions, determine a number of radial partitions such that discontinuities between adjacent k-space locations are reduced.

18. (Previously Presented) The MRI apparatus of claim 11 wherein the computer is programmed to carry out an elliptical centric phase order acquisition of MR data from at least one of a heart region and an abdominal region of a patient.

19. (Previously Presented) The MRI apparatus of claim 11 wherein the computer is programmed to partition k-space into partitions of similar size.

20. (Previously Presented) A computer readable storage medium having stored thereon a set of instructions that when executed by a computer causes the computer to:

partition k-space data into a number of partitions, each a given distance from a center of k-space;

play out a magnetic preparation pulse at a different rate for each partition, the rate being dependent on the given distance a partition is from the center of k-space;

acquire MR data in an elliptical centric order; and

play out a dummy acquisition following each of the magnetic preparation pulses.

21. (Previously Presented) The computer readable storage medium of claim 20 wherein each partition is centered about a center of k-space such that magnetic preparation occurs more frequently during MR data acquisition of a partition closer to the center of k-space than that of a partition farther from the center of k-space.

22. (Previously Presented) The computer readable storage medium of claim 21 wherein a rate of magnetic preparation pulses is non-zero for each partition.

23. (Previously Presented) The computer readable storage medium of claim 20 wherein the set of instructions further causes the computer to define boundaries of each partition and determine the number of partitions based on a k-space extent of a 3D image FOV.

24. (Previously Presented) The computer readable storage medium of claim 23 wherein the set of instructions further causes the computer to define the boundaries and the number of partitions such that k-space discontinuity between adjacent k-space views is reduced.

25. (Previously Presented) The computer readable storage medium of claim 20 wherein the rate for each partition is non-linearly dependent on the given distance a partition is from the center of k-space and wherein the set of instructions further causes the computer to play out a dummy acquisition following each magnetic preparation pulse and prior to data acquisition in each partition.

EVIDENCE APPENDIX:

-- None --

RELATED PROCEEDINGS APPENDIX:

-- None --